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ON THE EFFECTS OF POLARISATION WHICH RESULT FROM THE PASSAGE OF CURRENTS THROUGH BAD CONDUCTING MATERIALS.*

By the COUNT DU MONCEL.

In my preceding articles on the electric conductivity of ligneous bodies I showed that these substances are chiefly conductors by reason of the moisture they absorb. A similar effect is found in most minerals, and certain of them even possess this property so highly that very sensitive hygrometers may be formed of them. Calcareous stones of a fine grain, like the stone of Caen, are of this description; and the moisture pervading them in consequence of their contact with atmospheric air suffices to furnish, with zinc and copper electrodes fastened to the extremity of a small prism 10 c.m. in length, currents—varying with the moisture of the air—capable of affecting a sensitive galvanometer. Hard, uncrystallised stones, also, have a conductivity varying with atmospheric moisture, but to a less degree, whilst a moderately strong and prolonged heat will diminish it considerably. Like hard woods, these descriptions of stones, having slowly parted with their moisture, as slowly take it up again. Silica gives most curious effects. With regard to this I will give at a later date some details, and I will quote, at the same time, figures to represent the conductivities of different kinds of stones. At present I wish only to refer to certain effects of polarisation that presented themselves on studying the conductivities of these substances, and which are so far beyond known effects that grave errors might be committed if we contented ourselves with a superficial glimpse of them. The following experiment, wherein these effects showed themselves so great as to make it impossible to be overlooked, induced me to investigate them:—

Desiring to measure the conductivity of an exceedingly irregular piece of yellow silica, I enveloped the two extremities in very thin platinum plates, so shaped as to fit the irregularities of the ends; and to attach the plates more firmly to the stone, I used for the one end a small iron vice, for the other a copper nipper. On closing the circuit, the current from my bichromate of potash battery, of six elements, gave a deflection of 30°, and, leaving the whole concern to itself, I was surprised—at the end of ten minutes—to read a deflection of 43° instead of having to register a great diminution as results of polarisation,—a diminution which with calcareous stones, in the space of ten minutes, often becomes equal to half the first strength; and yet, by breaking the circuit and rejoining up the electrodes to the galvanometer, I was able to record a polarising current of 11°, which required ten minutes to completely disappear. By reversing the polarity of the electrodes—that is to say, by changing the electrodes' connections with the battery—I obtained at first a deflection of 55°, which became reduced at the end of ten minutes to 28°, and yet the polarising current was only 9°. A fresh inversion of the electrodes' polarities gave a deflection of 38°; but this did not rise to 43° at the end of the ten minutes, until it had fallen to 35° in the first moments of the experiment: the polarising current was 10°.

These experiments, repeated a great many times at different periods, and always with the same results, caused me to examine attentively the arrangement of the experiment. I ascertained that the increase in current strength by prolonging the closure of the circuit only took place when the iron vice was in connection with the battery's negative pole. On the other hand, on taking off my electrodes, I am sure that that which corresponded to the iron vice was slightly pierced by one of the stone's rough edges. Therefore the phenomenon was easily explained, for it was in consequence of a copper and iron local couple created in the heart of the stone, which—by interfering with the effects produced by the battery and by the polarising currents—modified them, in different senses, according to the direction of the battery current through the stone.

In the case in which the electrode in contact with the iron vice is in communication with the positive pole, only ordinary effects are produced. The local and battery currents flow in the same direction through the stone, like currents from two batteries joined in series placed in two different points of a circuit, and the strength of the battery current is naturally augmented by that from the local current. Hence we have the greatest observed deflection—viz., 55°—as compared with that produced under similar circumstances with the current reversed; and, since the effects of polarisation are as in ordinary currents, the diminution of deflection takes place in a continuous manner, only more rapidly than in liquids, on account of the slow dispersion of the polarising gases. Nevertheless, as at the moment of breakage of the battery current and of metallic reunion of the two electrodes, the polarising current becomes inverse in direction to that of the battery, whilst the local current remains under the same conditions, the polarising current which is collected is only a differential one, and might even be overcome by the polarising current, if the local current were sufficiently energetic.

In the instance when the oxidisable electrode (that in connection with the iron vice) is in communication with the negative pole of the battery, *that electrode receives the deposit of hydrogen* which provokes polarisation; and, as *the oxidation of this gas substitutes itself for that of the electrode itself which is more or less enveloped with it, three different effects may result therefrom, according to the relative energy of the electromotive forces of the local and polarising currents.* In the case when the local current is the most energetic, the effect of the cancelling of the metallic oxidation ought to result in *an increased force of the battery current, by destroying more and more the contrary force which had previously weakened it.* When the two electromotive forces are able to counterbalance each other, the strength of the current may remain sensibly the same, at least during a certain time. Lastly, when the polarising current's electromotive force overpowers it, the current should continue to become weak, but in a much less degree than when the battery and local currents are together. This effect I have been able to obtain in other experiments. Moreover, since—after breakage of the battery current and the metallic joining up of the electrodes—the local and polarising currents go forcibly in the same direction, and are able to develope themselves without hindrances, the resultant polarising current should be stronger than in the first example, which supposes the battery and local currents to be travelling in the same direction. When, after noting this action of the battery as resulting from these latter conditions, we return to that at first studied, we perceive the first action ought necessarily to be a weakening of the current; for the polarisation not ceasing instantly (evidenced in the previous experiments) continues, and adds itself in the first instance to the effects we have analysed, so as to augment in the beginning the battery current's strength, found, on account of its inversion, in the same direction as the remanent polarising current: afterwards the current is weakened, on account of the successive disappearance of the polarisation. It is quite true that a contrary polarisation soon follows, and produces the effects we have analysed. It is this complex effect which produced that primitive falling off of the deflection, followed by an increase, as seen in the previous experiments.

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* Communicated by the Author.

In order to justify my theory I reproduced the preceding phenomena from ordinary voltaic currents. I introduced into the circuit of my battery a local couple, composed of two plates, zinc and copper, separated from one another by 4 m.m. These plates joined together, so as to maintain constant the conditions of the experiment, were plunged into a glass of water rendered very slightly conductive, and I also introduced into the circuit a rheostat, together with a galvanometric sine compass of 100 turns. Then, to maintain the current of my battery constant, I placed in the circuit a resistance of 256 kilos.; and I changed the polarity of the zinc and copper electrodes by means of a commutator fitted to the rheostat, taking care to always keep the current in the same direction through my galvanometer, by placing it between the battery and the commutator.

With this arrangement, when the zinc plate was negative, a strength represented by 35° was obtained at the outset, and at the end of ten minutes by 35° 6′. Afterwards the polarity of the electrodes was changed, when a deflection of 39° 35′ was obtained, which became 37° 23′ after ten minutes' duration. These experiments, repeated again after an interval of ten minutes, gave in one instance a deflection of 34° 50′, which fell to 34° 10′ after five minutes, and attained 34° 19′ after the end of ten minutes; 34° 56′ at the end of twenty minutes; 35° 10′ after thirty minutes; and 35° 14′ at the end of forty minutes.

These experiments are completely conclusive, and I have been able, by modifying the conditions of the local current's energy,—either by disjunction of the plates or by changing the conductibility of the liquid,—to obtain, in the case which engages our attention, (1), immobility of deflection; (2), its continual enfeeblement, more or less rapid at will; (3), its increase, likewise more or less rapid. It is conceivable that this arrangement of the experiment might be profitably used, in certain scientific researches, to obtain an invariable current in a circuit composed of liquid parts. I may possibly, at a later date, point out some applications thereon.

To return now to the polarising effects immediately determined from electric transmissions through stones.

The experiments undertaken since the verification of the preceding effects showed me that they may be always met with, under one form or another, in all electric transmissions through stones. For in these bad conducting bodies there always exist local couples, and they may arise from many different causes,—either from the unequal dryness of the stone at the extremities in contact with the electrodes, or from the unequal extension of the metallic surfaces placed in intimate contact with the stone, or from the different state of the cleansed surfaces of the electrodes, &c. These currents have been already noticed in an article published in the "TELEGRAPHIC JOURNAL," vol. i., p. 46.

To settle the question as regards the effects of conductivity of mineral substances, it is indispensable to repeat each experiment with the current in both directions, especially as the presence of these local currents can only be definitely ascertained by the effects of which we have just spoken. It is rare, indeed, that by joining, to begin with, the electrodes to the galvanometer, appreciable deflections are obtained: it is necessary that the electrodes should be, in some fashion, over-excited in order to show them. The following experiments were made with a prism of Caen calcareous stone, 10 centimetres in length by 2 c.m. in width and 1 c.m. in thickness, and placed under different conditions:—

We commenced by satisfying ourselves of the importance of the local current, by joining up with the galvanometer the pincer and vice in communication with the electrodes. The determined deflections never exceed one or two degrees, and they have never been persistent—a particular character of these kinds of local currents. The platinum electrodes at that time entirely enveloped the extremities of the stone prism. After this first experiment the battery current was made to pass. Then, for a certain direction, a tolerably *fugitive* deflection was obtained at first: it stayed but for a short time at 77°, and became reduced—at the end of five minutes—to 58°, through giving place to a polarising current of 14°, which disappeared at the end of five minutes. After the reversal of the electrodes' polarities this deflection became at first 62°, to fall back to 53° five minutes after, with a polarising current of 14°, which again disappeared at the end of five minutes. A new change of polarities of the electrodes again raised this deflection to 66°; then it fell to 42° five minutes after, and the polarising current attained this time only 10°. Almost the first deflections were found again (58° and 53°) after these reversals of the polarities, and the polarising current remained equally the same, viz., 14°. A closure of the circuit effected at the end of five minutes, without reversal of the polarities, gave only 53° instead of 58°, and the same effect was produced with an opposed direction of the current.

In order to judge of the influence of the remanent polarisation on the electrodes, the apparatus was dismounted; the plates were wiped and replaced on the stone. The deflection, which had been 53°, now became 68°, and was only reduced 3° in the five minutes, by giving way to a polarising current of 18°, which in its turn disappeared in five minutes. The reversal of the electrodes' polarities raised the deflection to 71°, which was reduced to 57° at the end of five minutes, with a polarising current of 10°.

With double electrodes, and of smaller surface than the previous ones, a deflection of 37° for one direction of the current was obtained, which was maintained without diminution for ten minutes, with 8° of polarising current. The reversal of the electrodes' polarities raised this deflection to 50°, which fell to 16° after five minutes by giving way to a polarising current of 5°.

From these results it is easy to see that a local current was produced in the stone. Being very feeble, the polarising effects—for a certain direction of the battery's current—were only completely concealed by it in the second experiment; and its presence in the first could only be ascertained by the less value of the primitive strength, and by the less rapid decrease of this strength from the polarising effects. For the other direction of the current, on the contrary, the polarising effects manifested themselves by the greater value of the primitive strength and by its rapid fall. The polarising currents make themselves apparent, as the theory we have disclosed would indicate. It will be noticed that "rest" and "metallic reunion" of the electrodes do not completely destroy the polarisation developed within the stones; for the deflections which correspond to the closures of the current in one direction—after these rest intervals—remain almost the same as they were at the moment of breakage; and the change of direction does not alone suffice to efface it. There is only the separation of the electrodes of the stone, which can give place to the primitive strengths, frequently found exceeded in the early part of the experiments, by urging a diminution of the polarising effects.

If these performances are compared with those produced from woods, a great difference is met with; the effects of polarisation and the local currents are, so to speak, *nil* in them, and the same deflections are easily obtained. Thus, with ebony, for a current in a certain direction, 17° were at first obtained, which were only reduced 15·7° at the end of ten minutes, and the polarising current did not exceed 1°. For the other direction, and after ten minutes' interval, the deflection was 15° and 14·5° at the end of ten minutes, whilst 1° represented the polarising current.

ELECTRO DEPOSITION OF METALS.

By J. T. SPRAGUE.

THE depositing of metals in the various forms required in the arts depends upon the practical application of the theoretical principles which have been explained in previous papers; the processes divide themselves into two general groups—1. *Electrotyping.*—The forming of a mass of metal intended to have a distinct existence of its own, and requiring therefore to possess a certain amount of strength or coherence. 2. *Electroplating.*—In which a mere film of metal is to be employed as a covering to another metal, to beautify it or to protect it from atmospheric influences.

The essential distinction between the two processes is that in electroplating the two metals are desired to be brought into absolute molecular contact, so that they shall form one body mechanically considered; this depends entirely upon the absence of any intervening substance, that is to say, upon the absolute cleanness of the surface to be coated. Under ordinary circumstances every surface is coated with a very strongly adhering film of air, which appears to condense among the superficial molecules, and cling, as we see liquids do, to those surfaces which they can wet. This coating of air will prevent adherence unless it is very carefully removed; most metallic substances form either oxides or sulphides, and of course all collect a greasy film from the air, and the first and most essential operation is the removal of all these impurities, so as to present a pure metallic surface to the new metal to be incorporated with it.

In electrotyping, on the other hand, it is necessary to ensure the presence of an intervening film, which, while not resisting ordinary contact, will prevent true chemical or molecular contact. To effect this, after the surface to be deposited on (if metallic) is properly cleaned from everything which would deface the deposit, it should be lightly rubbed over with a leather or cloth moistened with turpentine in which a little bees'-wax has been dissolved—a piece the size of a pea to a quarter of a pint of turpentine will suffice, to prevent adhesion without filling up fine lines, &c.

The process of cleaning varies according to the nature of the objects and the solutions they are to be used with; these processes are *mechanical* and *chemical*. In mechanical cleaning it is desirable, if the objects will permit, to expose them first to a red heat, and then to rub and polish them thoroughly by means of suitable brushes and polishing substances. The best apparatus for the purpose consists of circular brushes mounted on a spindle driven by machinery or by a lathe. Circular pieces of wood, faced with leather, are also useful, as also the blocks of solid emery now so much used for grinding and polishing metals. A substitute for the latter may be usefully made by soaking a leather facing with glue, and coating well with emery, turning the wheel when nearly set against a roller, so as to consolidate the surface.

Most articles, however, are more rapidly and conveniently cleaned by chemical means. The first of these is the removal of grease by boiling in a solution of caustic soda, made by boiling 2 lbs. of common washing soda and ½ lb. quick-lime in a gallon of water; after this they should be well brushed under water. The further processes will depend upon the nature of the objects.

1. *Silver* is washed in dilute nitric acid, then dipped for a moment in strong nitric acid, and well washed. Care must be taken that the water does not contain chlorine salts; if the ordinary supply does so, the first rinsing after acids must be made in water prepared for the purpose by removing the chlorine by adding to it a few drops of nitrate of silver, and allowing the chloride to settle.

2. *Copper, Brass, and German Silver* are washed in a pickle of water 100 parts, oil of vitriol 100 parts, nitric acid (sp. gr. 1·3) 50 parts, hydrochloric acid 2 parts. Spots of verdigris should be first removed by rubbing with a piece of wood dipped in hydrochloric acid; they are then rinsed in water.

3. *Britannia Metal, Pewter, Tin, and Lead* cannot be well cleaned in acids, but are to be well rubbed in a fresh solution of caustic soda, and passed at

once, without washing, into the depositing solution, which must be alkaline.

4. *Iron and Steel* are soaked in water containing 1 lb. oil of vitriol to the gallon, with a little nitric and hydrochloric acids added. Cast-iron requires a stronger solution, and careful rubbing with sand, &c., to remove scale and the carbon left by acids. It is an advantage at times to connect them to a piece of zinc while cleaning. These metals should be cleaned just before placing in the depositing cell, and if they are to be placed in an alkaline solution they should be rinsed and dipped in a solution of caustic soda, to remove all trace of acids.

5. *Zinc* may be cleaned like iron, with a dip into stronger acids before the final washing.

6. *Solder* requires special care, as the acids used with the objects produce upon it an insoluble coating, and an obstinate resistance to deposit is set up at the edge of the solder. The same remark applies to soft metal edgings and mounts. These should be rubbed with a strong caustic soda solution, rinsed, and then treated as follows:—Make a weak solution of nitrate of copper by dissolving copper in dilute nitric acid; to a camel-hair or other soft brush tie three or four fine iron wires to form part of the brush; dip this in the nitrate of copper, and draw over the solder, taking care that some of the iron wires touch it; a thin adherent film of copper will form, and upon this a good deposit will take place.

7. *Old Work* for re-plating must have the silver and gold carefully removed; if this is not done, there is apt to be a failure of contact at the edges of the old coatings, which causes blisters and stripping under the burnisher. The best mode of stripping is with the scratch brush, &c., as described for mechanical cleaning, but chemical means may be used. *Gold* is dissolved by strong nitric acid, to which common salt is gradually added; it may be collected afterwards by drying and fusing with soda or potash. *Silver* is similarly dissolved by strong sulphuric acid and crystals of saltpetre, and recovered by diluting and precipitating with hydrochloric acid, then reducing the chloride either by fusion with carbonate of soda, or by acid and zinc cuttings. *Copper* can be removed from silver by boiling with dilute hydrochloric acid, and *tin* and *lead* by a hot solution of perchloride of iron.

In preparing articles for silvering and gilding, a process of *amalgamation* is very commonly employed, by which a very thin film of mercury is formed over the surface, which makes a perfect connection between the two metals; this is effected by a solution of 1 ounce of mercury in dilute nitric acid, and then diluted to one gallon; there must always be a little free nitric acid present; articles dipped in this solution take a greyish colour, which on brushing under water becomes a brilliant mercury surface. They must be at once transferred to the solution for coating, without exposure to the air. In the case of iron or steel articles, a similar process may be used, but in this case it is best to add to the solution an ounce of silver also dissolved in nitric acid; it requires great care to obtain a perfect mercury surface upon iron; occasionally sodium-amalgam is rubbed over iron for this purpose; the iron must be very perfectly cleaned first.

The connecting wires should be secured to the objects while under water, unless, which is much better, they can be soldered on before cleaning; it is usually better to have two or three wires to an object, so as to diminish the resistance, and to shift the points of contact occasionally, in order to avoid furrows upon the face; it is better also to make the actual contact by short pieces of fine wire attached to a larger conductor not in contact with the object. The general principle to be kept in view is to make the resistance of these connecting arrangements as small as possible, and yet to avoid anything which shall interfere with the contact of the liquid and its free circulation over every part of the surface to be coated.

According to the conditions we set up will be the nature of the metal deposited,—that is to say, its molecular condition as to cohesion, &c., will depend upon the relations of force to which the deposit is exposed. Colour also depends, in great degree, upon the molecular condition of the surface; for instance, gold in very thin films has a greenish tint, owing to the light reflected through it; in a very finely divided state, as when chemically precipitated it is a dark brown; in its ordinary condition, also, the presence of very small quantities of copper and silver greatly modifies the colour. To secure deposits of good quality and appearance, therefore, it is desirable to ascertain those relations of energy which set up the conditions upon which good deposit depends.

If we pass a strong current into a weak solution of copper, the metal deposited will be pulverulent: if, by means of resistances and varying battery power, we pass a fixed current into a solution, but effect the deposit upon a surface of gradually diminished area, a series of instructive results will be obtained. If the surface is very large in proportion to the current, the deposit will form in separate crystalline granules, chiefly on the edges and corners, and a deposit formed under these circumstances will develope into a series of nodules capable of easy separation from each other. If the surface is small compared to the current, the deposit will be of a brown colour, and have no coherence: this state, also, will begin to show itself first at edges and corners; there the deposit may be quite friable, while a good metal is forming at the middle of the plate. The principles of liquid conduction, explained p. 292, account for these effects, by showing that the current acts in a higher degree at points and edges, just as charge does in static electricity, because at these there can be set up the most numerous lines of polarisation towards the opposing surface. We learn, in fact, that there are two sets of conditions to be attended to.

The first point is the *strength of solution*. If we pass a strong current in a weak solution we get the brown powder; if, without altering any other condition, we add saturated solution of the metal, the deposit may become good. In every solution there are several different *ions* present at the electrodes; thus, in the case in point, with a weak solution only a small part of the cathode can have copper turned towards it; by far the greater portion of its surface must be in contact with the hydrogen of the water or acid: the conditions are, in fact,—

$$\text{Cathode}\left\{\begin{array}{ll} CuSO_4 & H_2SO_4 \\ H_2SO_4 & H_2O \\ H_2O & CuSO_4 \\ H_2O & H_2SO_4. \end{array}\right.$$

Now, if the current (or quantity) is larger than the

Cu is equivalent to, of course H_2 is set free, and this will reduce a neighbouring atom of copper, *but not in contact* with the electrode,—that is to say, the deposit will consist of detached molecules, and most likely of a compound of copper and hydrogen. This would not occur if the current also were weak, because a weak current means a low tension at the electrode, and, as was seen at p. 308, hydrogen can be set free only when a certain tension has been reached sufficient to supply the requisite *specific energy;* besides, the slow current would be able to find sufficient copper in even a very dilute solution.

It is obvious, therefore, that solutions should be sufficiently supplied with metal for all likely requirements, and the stronger they are the more rapidly they are to be worked, up to limits which will be considered at another stage.

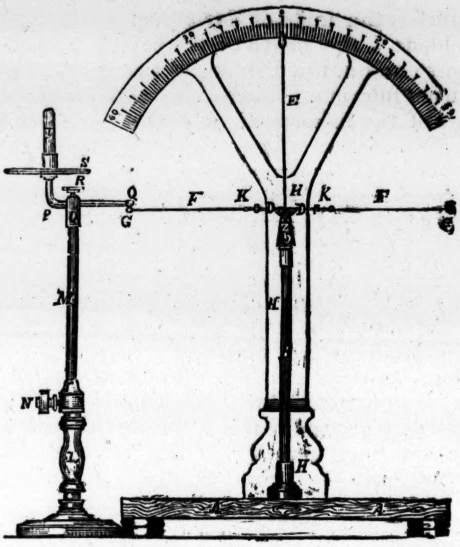
The other point to be studied is the relation of the *current* to the solution and to the work, and this is the most important, because it is under control and is constantly varying with different objects. We have seen that there is a point so near balance that the extra strength of current concentrated on the edges destroys the coherence of the deposit. Now if we arrange several vessels in series, all alike except in the difference in the area of the cathode in each, and connect them to a battery, we can produce such a condition of things that by the *same current and from the same solution*, and with the *same size of anode*, we shall obtain every gradation of deposit, from brown loose powder to single hard crystals. Here, then, we find a relation between the "quantity" or current and the *area* over which it is distributed,—a relation which is rarely pointed out with the definiteness required, for this is the fundamental condition of good working. Of course this is practically known, or there could be no success in depositing, but the principle can only be understood by a distinct conception of measurement, and of those molecular relations of electricity which have been examined in former articles, in which, for this reason, I have sought to fix upon the mind a distinct conception of the minute construction of matter and its elementary properties.

This relation we may examine under the name of *density of current*, for which also we require a unit: this is conveniently furnished by the "chemic" unit of current and square inch of surface. We must therefore ascertain, by experiment, for any given solution, the range of "density of current" which gives good work. Such an experiment is made by using a cathode of a fixed area, so that by varying the battery power we can examine the different quality of deposit produced. Having thus ascertained the rate of deposit adapted to the solution, the density of current can be controlled by similar means in actual working, so as to secure the conditions of good working and the rate and quality of deposit we desire, the conditions for which are next to be examined.

ON A NEW TANGENT-ELECTROMETER FOR LECTURES.

By Ph. CARL.

About two years ago H. Bourbouze described a lecture-galvanometer which renders the feeblest effects of the current visible for a large audience. The author has come upon an arrangement which unites very great sensibility with the advantage that the electric phenomena can be recognised at a great distance, and which can be adapted for the execution of absolute measurements. The instrument is represented in the figure $\frac{1}{12}$th its size.



Upon a wooden support, A A, stands an insulating glass rod, B, which supports a brass fork, C, provided above with steel bearings. In these lies the knife-edge of a short brass balance-beam, with which is connected a long index, E In the ends of the arms of the balance fine glass tubes (such as are used for vaccine lymph) are cemented, F F, covered with shellac varnish, and bearing at their ends the elder-pith balls, G G. Behind this balance there stands upon the same footboard, A A, a wooden support, H H, with the scale, J J. On the balance-arms is cut a screw thread, by means of which the weights K K—made in the form of female screws—can be set so as to bring the index E to the zero point of the scale. Below the balance-beam there is a weight, Z, to regulate the distance from the centre of gravity to the fulcrum. It is concealed by the fork C, and is therefore represented in the figure by a dotted line. If vulcanite is very slightly rubbed upon fur, and approached to the elder balls, G G, even at a considerable distance, the maximum indication of E is obtained.

The electrometer can be combined, in a very simple manner, with a condenser. In the wooden foot L the perpendicular glass rod M can be raised or lowered, and fixed at any height desired by means of the screw N. The rod M terminates above in a vulcanite support, O, through which passes the brass wire P, bent at right angles, and bearing at one end the small brass ball Q, and at the other the horizontal copper disk R, upon which the condenser-plate S can be placed by means of the insulating glass handle, T. The plates R and S can be unscrewed and replaced by others, as may be requisite. In cases where no condenser is required the plate R may be removed, and a simple brass ball fixed in its stead. The apparatus is not merely an electroscope, but an electrometer. If the disc R is replaced by a brass ball connected with any source of electricity, the ball G will be repelled to an angle a, and the magnitude of the repelling force is then proportional to the tangent of the angle of deviation.

If we take the formula of sensibility of the balance, it is—

$$tg\,a = \frac{p\,l}{g\,.\,d};$$

a signifies the angle of deviation; p, the weight to be added; l, the length of the balance-beam; g, its weight; and d, the distance of the centre of gravity from the fulcrum. Since l, g, and d are the constants of the balance, if we put—

$$\frac{l}{g\,.\,d} = C,$$

then $tg\,a = C\,.\,p$. If, inversely, we put—

$$\frac{g\,d}{l} = C',$$

then $p = C'\,.\,tg\,a$. The "weight to be added" is the amount of the repellent force, and is therefore proportional to the tangent of the angle of deviation.

In order to determine the constant C′ it is merely requisite to append to the pith ball G a centigramme rider, and to observe a. If this angle is found to be a_1 we have—

$$C' = \frac{1 \text{ centigrm.}}{tg\,a_1}$$

We can thus represent the force of the electric repulsion in weight, and possess thus a tangent-electrometer. The balance can be rendered more or less sensitive by means of the weight Z. If accurate measurements are required the whole apparatus must be enclosed in a glass case, through the side of which the wire P is passed, with proper provision for insulation.

INDUCED CURRENTS AND DERIVED CIRCUITS.

By SAMUEL E. PHILLIPS, Jun.

In the "Journal of the Society of Telegraph Engineers" I have recently noticed an article with the above heading, extracted from "Silliman's American Journal," in which the writer, Mr. John Trowbridge, seems under the impression that the law of derived circuits, as ordinarily understood, does not apply to induced currents; and after giving some data, in which several important items are missing, he concludes by saying—"From the above it appears that, under certain conditions, an induced current does not divide according to the laws of derived circuits, but approximates to these laws when there is a resistance exterior to the galvanometer, which is appreciable in comparison with that of the galvanometer." This is doubtless a very startling statement in itself, and, being copied from one journal into another, may mislead many, who let it pass unchallenged. A little consideration of the figures given will, however, soon make the matter clear, and leave us in full possession of the laws attacked, and of their universal application.

In dealing with derived circuits, Mr. Trowbridge would seem to ignore the fact that for every alteration in the combined resistance—such as the variations in the shunts of a galvanometer—the total resistance in circuit is altered, and, consequently, we have not the same quantity of current flowing in any two cases. The electromotive force being constant, and the internal resistance of the electromotor (whether battery or coil) being so small that it may be disregarded, then it is easy to see that with any shunt we shall in all cases obtain about the same deflection on the galvanometer, a constant deflection in the case of a battery, or an impulse of constant force when dealing with an induced current. The laws of derived circuits apply with equal exactness in each case: this we can clearly show by Mr. Trowbridge's own figures, although he draws a contrary inference from them. He says—"A reflecting galvanometer of large resistance was included in the secondary circuit, and connected by copper wires of very small resistance with the coil in which the secondary currents are produced: *the resistance of these wires was infinitesimal in comparison with the resistance of the galvanometer*." This is somewhat vague, for it would lead one to suppose that it was only the leading wires which had an infinitesimal resistance in comparison with the galvanometer, and that he had omitted to mention the resistance of the secondary circuit in which the induced current was produced; and one might naturally picture the secondary circuit of an induction coil as the source of current, in which case there would ordinarily be a considerable resistance involved; but a glance at the figures show that this was not the case, and that the infinitesimally small resistance included both the leading wires and the coil under induction; and a little later this is further indicated, for the writer says—"With an inappreciable resistance outside the galvanometer coils, the shunts made no difference in the deflection of the galvanometer needle when the shunts were not less than 3 ohms; below this the current divided"! —the last five words conveying the idea that previously no division had taken place, which is later on contradicted, in instancing one galvanometer shunted by another galvanometer of the same resistance, the same deflection being obtained on each, when joined as a parallel circuit, as upon one alone. How Mr. Trowbridge could have come to this last result, and not have seen the true bearing of the case, it is hard to understand. With his galvanometer of 5880 units resistance he obtains a deflection of 210 divisions, the resistance external to the galvanometer practically equalling 0. And we may express it thus, E being the electromotive force of the induced current—

$$\frac{E}{5880} = 210 \text{ divisions.}$$

On shunting the galvanometer with an equal resistance we have—

$$\frac{E}{\dfrac{5880 \times 5880}{5880 + 5880}} = \frac{E}{2940} = 420 \text{ divisions;}$$

or, having halved the total resistance in circuit, we get a current of double quantity, which, having two equal channels to flow through, divides into two halves, 210 going through the galvanometer, as in the first case when no shunt was employed, and 210 by the shunt; whereas Mr. Trowbridge would seem to infer that, had the law of divided circuits been correct. we should have obtained only 105 divisions, which would have been quite true if we had been simply dealing with a given amount of current in the several cases. We therefore see that

$Q = \frac{E}{R}$ is a perfectly correct expression to use in connection with an induced current, and that, having by this equation correctly estimated the amount of current in each case, it is found to divide strictly according to the law of derived circuits.

Mr. Trowbridge next goes on to show that with only small added external resistances,—such as 10, 20, 30, 40,—the galvanometer being shunted with 588 units, and consequently having a combined resistance of 534·55 units in each case, he still obtains 210 divisions, and the shunt of 588 ohms has no effect. Here there is a departure from the values we should predict, following our previous simple estimate of the case; they are, however, not great, and in the absence of all instrumental data I should be inclined to consider the theoretical values correct, and the departure from them to be due to errors in the method of making the investigation. In the first case we have—

$$\frac{E}{5880+10} = 210,$$

and with a shunt introduced—

$$\frac{E}{\frac{5880\times5880}{5880+5880}+10} = \frac{E}{2950} = 22676,$$

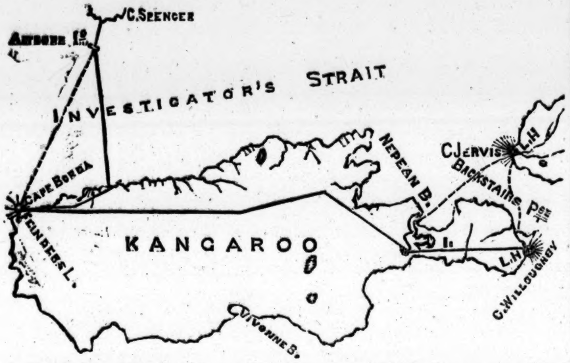
which dividing inversely between the galvanometer and shunt, we should have 206 pass through the former, and not 210 as stated. On adding 100 units external resistance, the table gives the deflection as 190 instead of 210, whereas calculation similar to to the above would give us the following values:—

$$\frac{E}{\frac{5880\times588}{5880+588}+100} = 177$$ divisions on the galvanometer instead of the 190 given.

Mr. Trowbridge then adds, that—"We see from this that no effect is produced by the shunt until the exterior resistance was appreciable in comparison with that of the galvanometer." We can only remark, *of course not!* And we have already shown that, with an exterior resistance of 0, the shunt has absolutely no effect on the current flowing through the galvanometer, but the moment we have external resistance the shunt begins to produce a reduction in the current passing through the galvanometer; as in the case of the 10 added units of external resistance, 206 divisions would have been obtained instead of 210, although Mr. Trowbridge's arrangement did not seem to appreciate such small differences. We may, in this way, go on increasing the external resistance until any shunting of the galvanometer alters the total resistance in circuit, by so small an amount that the deflections become practically quite proportional to the two resistances. Mr. Trowbridge then gives a table to show the effect of considerable external resistances, such as 1500, 2000, 2500, 3000 ohms, and so on up to 5000. I have endeavoured to understand the construction of this table, but have quite failed to trace the relative values given, and will simply quote the paragraph that follows:—"It will be seen, by comparison, that with large external resistances exterior to the galvanometer resistance, and appreciable in connection with it, the laws of the division of currents practically hold, and as the exterior resistance approaches that of the galvanometer the coincidence of the laws is more marked." ! We would rather say—The laws of derived circuits apply with equal exactness to continuous voltaic currents and to currents due to induction. In the latter case, as in the former, when the external resistance is inappreciable with that of the galvanometer, the current flowing in the galvanometer is unaffected by a shunt; when the external resistance is appreciable in connection with the galvanometer resistance, the effect of the shunt becomes visible, and the more we increase this external resistance the more proportional do the deflections become, until, with infinite external resistance, they would be exactly so, and a given current—whether voltaic or induced—would divide between the two circuits in the exact inverse ratio of their resistances, provided the two wires were placed under exactly the same conditions. If this latter were not the case a small apparent departure from the law might take place, as instanced in a paper read before the Society of Telegraph Engineers, by Mr. Latimer Clark, in which it is pointed out that when a galvanometer is shunted a given momentary current does not divide exactly in the inverse ratio of the two resistances. We could also imagine a similar apparently abnormal result in two circuits, one of which was laid out straight and the other coiled up on a bobbin,—but these are refinements beyond the field of Mr. Trowbridge's somewhat sweeping discovery; but even with them we would suggest that the law, in its widest bearing, is still perfectly correct, for in the first case the apparently abnormal result is due to an opposite current, being set up in the galvanometer coil by the swing of the needle, and so the primary current is retarded in this part of the circuit, and the shunt carries more than its due share; so in the case of the straight and the coiled wire, there would be an inductive action between the coils of the wire on the bobbin, which we can imagine would prevent an exactly equal division of a given momentary current, although their two resistances might with other conditions be equal; and it would surely be unfair, on this account, to say the simple law is incorrect: let us rather adhere to it, and then when we meet with any difficulty—such as suggested above—we should be led to look for some external cause, and should in all cases doubtless find one to exist.

ESTABLISHMENT OF A TELEGRAPH STATION IN INVESTIGATOR'S STRAITS (SOUTH AUSTRALIA).

The number of telegraph stations which are established for no other purpose than that of signalling passing vessels is year by year steadily increasing, and the advantages which are derived from them are so manifest that the want of others in various quarters of the globe is becoming every day more and more felt. It is gratifying to find that our Colonial Governments are, as a rule, fully alive to the importance of the subject. The House of Assembly in South Australia has had before it the proposal to establish such a station at some point in Investigator's Straits,—a strip of water separating Kangaroo Island from the southern extremity of Yorke Peninsula, and forming the entrance to the Gulf of St. Vincent, upon which Port Adelaide is situated. Various ways of effecting this have been suggested by Mr. Todd, the Postmaster-General and Superintendent of Telegraphs at Adelaide; but that which appears the most feasible, and meets with the sanction of the President of the Submarine Board, Mr. Ferguson, is an extension of the land lines from Moonta—the present terminal—down the Peninsula to Cape Spencer, the southern extremity; thence lay a heavy cable to the Althorpe Islands, on the northern side of the Straits, and continue it across to Cape Borda, the north-westerly point of Kangaroo Island,—a distance of about 20 miles. The minimum estimated cost of carrying this out is £20,000. There would then be two telegraph stations,—one on the north side of the Straits, on the larger Althorpe, which would be made by the vessels sailing *eastward;* the other on Cape Borda, in Kangaroo Island, which is the nearest or first point of communication from the *westward* on arrival, and likewise the last on departure. In this way all vessels desirous of being reported could, in the event of unfavourable winds for reaching one station, make for the other.



The collateral advantages which would be derived from the execution of this scheme are not to be overlooked: in addition to bringing Kangaroo Island into direct communication with the mainland, the line, as it runs through Yorke Peninsula, would afford telegraphic facilities to the growing population of the southern districts, who, we are not surprised to hear, are already beginning to cry out that these are urgently required.

Students' Column.

Resistances and their Measurement. By H. R. Kempe.

Continued from p. 326.)

XIV.—In a previous article we gave several methods of finding the electromotive forces of batteries. Another very simple and quick method is that of charging a condenser from the batteries whose electromotive forces are to be compared, and then noting the discharge deflections. The forces will be directly proportional to these deflections. Discharge deflections on a galvanometer whose deflections are truly proportional to *constant* currents producing them, unless they are nearly equal, are rarely proportional to the currents which produce them. It is therefore very desirable, in measurements such as these, in order to ensure accuracy, to adopt the method we mentioned in the last article, viz., to obtain a uniform deflection by means of a variable shunt to the galvanometer. Thus, if we obtained two similar discharge deflections with two different electromotive forces, E_1 and E_2, using shunts of the respective resistances S_1 and S_2 for this purpose, we should have—since the deflections are the same—that the electromotive forces are to one another in the proportion—

$$E_1 : E_2 :: \frac{G+S_1}{S_1} : \frac{G+S_2}{S_2},$$

or as the multiplying power of the shunts, G being the resistance of the galvanometer. For if we multiplied the deflection we obtained by these quantities, we should obtain the theoretical deflections we should have had, had no shunts been used. For example, with an electromotive force E_1 we obtained a discharge deflection of 300° on a galvanometer whose resistance G was 5000 ohms, using a shunt, S_1, of 1000 ohms, and with a second electromotive force, E_2, also a deflection of 300°, using a shunt, S_2, of 2500 ohms. Then—

$$E_1 : E_2 :: \frac{5000+1000}{1000} : \frac{5000+2500}{2500},$$

that is—

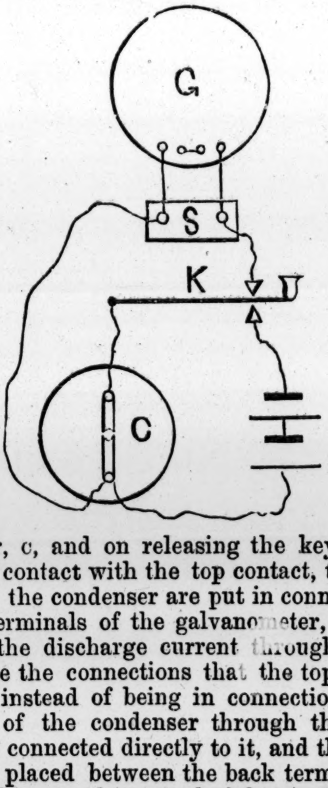
$$E_1 : E_2 :: 2 : 1;$$

the theoretical deflections we should have obtained had no shunts been used being 1800° and 900° respectively, that is—

$$\frac{5000+1000}{1000} \times 300^\circ \text{ and } \frac{5000+2500}{2500} \times 300^\circ$$

To take these discharge deflections we should make use of the condenser and the discharge key given in the last Article. The connections would be made as shown by Fig. 24. On pressing down the discharge key, K, the two poles of the battery are put in connection with the two terminals of the condenser, C, and on releasing the key so that it comes in contact with the top contact, the two terminals of the condenser are put in connection with the two terminals of the galvanometer, which thus receives the discharge current through it. If we so arrange the connections that the top contact of the key, instead of being in connection with the terminal of the condenser through the galvanometer, is connected directly to it, and the galvanometer is placed between the back terminal of the key and the second terminal of the condenser; then

Fig. 24.



on pressing down the discharge key we get the current charging the condenser through the galvanometer, which has its needle deflected to one side of the zero point; and then, on releasing the key, we get the discharge deflection, which will be of the same strength as the charge deflection, but in the opposite direction to it. The first arrangement, given by the figure, is, however, the one generally employed.

The discharge deflection on the galvanometer is only a momentary one, the needle or spot of light immediately returning to zero. If the Thomson galvanometer is used for measuring the discharge, which it is best to do, the adjusting magnet must be put sufficiently high up, if it is placed with its poles assisting the earth's magnetism, or low down if it opposes it, to make the needle swing slowly enough to enable the deflection to be read on the scale. It is best to avoid making the needle swing very slowly, for then the spot of light will probably not return accurately to zero, but may be three or four degrees out. A little practice will enable a comparatively quick swing to be read to half a degree, or even less.

Besides determining the electromotive force of a battery, we can also determine its internal resistance with great facility by means of a condenser. To do this, first charge the condenser by means of the battery, and note the discharge deflection, which we will call α°; next insert a shunt, S, between the poles of the battery; again charge and discharge the condenser, and note the new deflection, which we will call β°. Now, the amount of deflection produced on a galvanometer needle depends upon the difference of potential on either side of it, and similarly in a condenser, the strength of the charge it takes up depends upon the difference of potential on either of its terminals. We may therefore regard a condenser as a galvanometer, but one having a very high resistance. Let us call G this resistance, and let E be the electromotive force of the battery, and R its internal resistance.

First we have, before the shunt is inserted,—

$$\alpha^\circ = \frac{\mathrm{E}}{\mathrm{R}+r}, \text{ therefore } \mathrm{E} = \alpha^\circ(\mathrm{R}+r);$$

next, inserting the shunt, we have current passing out of battery equals—

$$\frac{\mathrm{E}}{\mathrm{R}+\frac{r\,\mathrm{S}}{r+\mathrm{S}}},$$

and current passing through galvanometer—

$$\beta^\circ = \frac{\mathrm{E}}{\mathrm{R}+\frac{r\,\mathrm{S}}{r+\mathrm{S}}} \times \frac{\mathrm{S}}{r+\mathrm{S}};$$

therefore—

$$\mathrm{E} = \beta^\circ\,\frac{\mathrm{R}\,r+\mathrm{R\,S}+r\,\mathrm{S}}{\mathrm{S}}.$$

Equating the two equations we get—

$$\alpha^\circ(\mathrm{R}+r) = \beta^\circ\,\frac{\mathrm{R}\,r+\mathrm{R\,S}+r\,\mathrm{S}}{\mathrm{S}};$$

therefore—

$$\frac{\alpha^\circ}{\beta^\circ} = \frac{\mathrm{R}\,r+\mathrm{R\,S}+r\,\mathrm{S}}{\mathrm{R\,S}+r\,\mathrm{S}} = \frac{\mathrm{R}+\frac{\mathrm{R\,S}}{r}+\mathrm{S}}{\frac{\mathrm{R\,S}}{r}+\mathrm{S}},$$

and since G is very great compared with the other resistances, we may put $\frac{\mathrm{R\,S}}{r} = 0$; therefore—

$$\frac{\alpha^\circ}{\beta^\circ} = \frac{\mathrm{R}+\mathrm{S}}{\mathrm{S}},$$

therefore—

$$\mathrm{R} = \mathrm{S}\,\frac{\alpha^\circ-\beta^\circ}{\beta^\circ};$$

or if S is adjusted till $\frac{\alpha^\circ}{2} = \beta^\circ$, then—

$$\mathrm{R} = \mathrm{S};$$

but as it does to follow that because β° is half α°, that therefore the strength of the discharge is halved; or, indeed, that α° and β° are proportional to the discharges which produce them, we must adopt some other way of making the measurement. The most accurate method of making the test would be the following:—Join up the galvanometer, discharge key, battery, and condenser, as shown in Fig. 24, and shunt the galvanometer until a convenient discharge deflection can be obtained on the scale; note this deflection (α°) and the resistance of the galvanometer shunt S_1; next insert a shunt S between the poles of the battery of a resistance sufficient to about halve the discharge deflection on the scale. Now increase the resistance of the galvanometer shunt to S_2 until the deflection becomes α°, as at first; we then get—

$$\mathrm{R} = \mathrm{S}\,\frac{\alpha^\circ\,\frac{\mathrm{G}+\mathrm{S}_1}{\mathrm{S}_1} - \alpha^\circ\,\frac{\mathrm{G}+\mathrm{S}_2}{\mathrm{S}_2}}{\alpha^\circ\,\frac{\mathrm{G}+\mathrm{S}_2}{\mathrm{S}_2}} = \mathrm{S}\,\frac{\mathrm{G}\,(\mathrm{S}_2-\mathrm{S}^1)}{\mathrm{S}_1\,(\mathrm{S}_2+\mathrm{G})}$$

For example:—With a galvanometer whose resistance (G) is 5000 ohms (which would be about the resistance of a Thomson's galvanometer) we obtained, with the unshunted battery, a discharge deflection of 300°, using a galvanometer shunt (S_1) of 1000 ohms. On inserting a shunt (S) between the poles of the battery of a resistance of 240 ohms, which about halved the deflection, it was found necessary to increase the galvanometer shunt to a resistance (S_2) of 2200 ohms, in order to reproduce the original deflection of 300°, what was the resistance of the battery.

$$\mathrm{R} = 240\,\frac{5000\,(2200-1000)}{1000\,(2200+5000)} = 200.$$

A possible source of error in this kind of test may arise from one measurement being made with the battery unshunted, when no action goes on in it, and the second being made with it shunted, which may cause a falling off in its electromotive force, as action would be then going on. The accuracy of the test depends upon the electromotive force being constant in both ends.

When comparing large electromotive forces with small ones—as, for instance, 100 cells with 1 cell—the smaller force should be taken first; for a large charge usually leaves a residuum in the condenser, which may be greater than the small force, and which can only be thoroughly dissipated by leaving it (the condenser) short-circuited for some time. If the smaller force is measured first, then any residuum it may leave becomes entirely swamped by the larger force, and no increase of charge is added to the condenser beyond what the force itself possesses, Although the condenser practically becomes charged instantaneously, it is best to keep the current on for a definite time, such as half a minute or a minute. We shall then be certain that it has become thoroughly charged. Especial care must be taken to insert a shunt of a small resistance in the galvanometer at first, when measuring discharge currents, as they are very liable to demagnetise or weaken the magnetism of its needles when strong currents are used. If this precaution is not taken a set of measurements for one test may be rendered useless, as a comparison of measurements made before the magnets became weakened with measurements taken after would be obviously impossible, and much loss of time result.

Electrostatic Capacity.—The measurement of electrostatic capacity by means of a condenser is a very simple operation. To compare condensers of unknown capacity with a standard condenser we have simply ~~to~~ note the discharge deflection (a°) given by the standard condenser (C), and then that given by the other condensers (a_1), (a_2), &c., and their capacities (C_1), (C_2), &c., will be to the standard directly as their discharge deflections, taken with the same battery power, or—

$$C : C_1 : C_2 :: a^\circ : a_1^\circ : a_2^\circ.$$

Thus, for example, if the standard condenser had a capacity of $\frac{1}{3}$ microfarad, and gave a discharge deflection of 300°. And suppose two other condensers, C_1, C_2, gave discharge deflections of 225° and 180° respectively, then—

$$\tfrac{1}{3} : C_1 : C_2 :: 300^\circ : 225^\circ : 180^\circ;$$

that is—

$$C_1 = \tfrac{1}{3} \cdot \frac{225^\circ}{300^\circ} = \tfrac{1}{4} \text{ microfarad,}$$

and—

$$C_2 = \tfrac{1}{3} \cdot \frac{180^\circ}{300^\circ} = \tfrac{1}{5} \text{ microfarad;}$$

or using shunts to obtain the same deflection, we should have—

$$\tfrac{1}{3} : C_1 : C_2 :: \frac{G+S}{S} : \frac{G+S_1}{S_1} : \frac{G+S_2}{S_2}.$$

In measuring the electrostatic capacity of a cable we should have the further end insulated, the nearer end joined to the back terminal of the discharge key, and the two wires—which in Fig. 24 are shown as joined to one terminal of the condenser—put to earth, the other connections being the same as shown in that figure. Then, as before, the capacity of the cable will be to the capacity of the condenser as the discharge deflection of the one is to the discharge deflection of the other, or obtaining the same deflection, by means of the shunts, as the multiplying power of the shunts. The capacity per mile will be the result divided by the mileage of the cable.

Other methods of measuring the capacity of cables we shall consider hereafter.

(To be continued).

Notices of Books.

Mr. Herring and the Telegraphs: Present Position of the Question. Longmans and Co. August, 1874.

"Mr. Richard Herring is the inventor of an improved method of printing telegraphic messages," we are informed in the first sentence of a pamphlet, bearing the above title, which has lately reached us. In his system the dashes and dots of the ordinary Morse alphabet are made by separate styles or pointers, and they are transverse to the strip of paper which receives them, instead of longitudinal. The principle is exactly the same as that introduced by Steinheil, and various efforts have from time to time been made to gain some practical advantage from it over the Morse. All, however, have failed, and Mr. Herring's is doomed to share the common fate. Without entering into the merits or demerits of the system—a task which would occupy more space than we have at our disposal—we may briefly state that, as far back as the latter end of 1870, Mr. Herring seems to have brought his invention ueder the notice of the Post-Office Authorities, and, with the characteristic zeal of all inventors, to have persecuted them on the subject ever since. The heads of that Department appear to have acted in an exceptionally generous manner towards him: they engaged the two first electricians of the age, Sir Wm. Thomson and Mr. Fleeming Jenkin, to examine the working of the apparatus and form an estimate of its value. Mr. Herring being dissatisfied with their report employed Messrs. Clark, Ford, and Co. to act on his behalf. The experiments were conducted upon wires placed by the Post-Office at Mr. Herring's disposal; and Messrs. Thomson and Jenkin, after stating that "Every facility has been given by the Post-Office and by Mr. Herring for a full and satisfactory trial of the instruments, under all conditions," are "with much regret obliged to report that, in their opinion, Mr. Herring's system is not preferable to the usual Morse system, either as to speed or efficiency." Thereupon Mr. Herring, on the principle apparently of having "no case," roundly abuses, in this pamphlet, Mr. Scudamore, the Director, and Mr. Culley, the Chief Engineer of the Government Telegraph Department, against the latter of whom he is unusually severe. Taking advantage of confidential reports which had accidentally made their way into his hands, he gives some disjointed extracts from these, and then proceeds to inform us (page 15) that "it is no exaggeration to say that they (Mr. Scudamore and Mr. Culley) regard any outsider who suggests an improvement in telegraphy as a common enemy, against whom they must combine forces and exert all their ingenuity for his defeat." Coming across such statements as this, and looking at the opinion which the highest possible authorities have formed as to the value of his invention, we cannot help thinking that had Mr. Herring calmly consulted his own interests for a moment, he would have avoided rushing into print at all upon this subject.

Correspondence.

OPTICAL NOCTURNAL TELEGRAPH.

To the Editor of the Telegraphic Journal.

Sir,—I find in the number of your valuable journal for the 15th October an abridgment of an article which appeared in No. 17 of *Revista de Telegrafos*, concerning an optical nocturnal telegraph. I published precisely the same method in the month of July, 1873, at which time I was directing the experiments of the electric light on the Tower at Westminster. The principal end which I proposed was to establish a means of correspondence by day and night between the semaphores, and to communicate from the deck of one ship to another. A special arrangement of the holophote ought, at the same time, to render any collision impossible, each vessel being easily able to perceive the course of the other. I therefore lay claim to priority of the discovery, and I shall be glad if you will kindly give my claim a place in the next number of your journal.—I am, &c.,

R. WERDERMANN.

Electrical Science in English and Foreign Journals.

(In addition to our usual abstracts, there will be found under this heading the titles of papers on electrical science which have appeared in English and foreign journals from the commencement of the present century up to the date of the establishment of this journal).

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxix., No. 10. September 7, 1874.

Note on Magnetism (continuation).—By F. M. Gaugain.—Pars. Nos. 74 to 78.—"When an armature of soft iron is fitted against the polar faces of a horse-shoe magnet, the magnetisation is increased throughout the whole extent of the magnet. This seems to render the theory incompatible that the phenomenon* results from magnetic matter which becomes condensed in the neighbourhood of the poles. It may be explained thus, by adopting Ampère's theory:—The action of the magnet is to impress a rotary movement on the molecules of the armature placed near its surface, and causes them (the molecules) to approach more or less the magnetic inclination. The armature, now become a magnet, reacts in its turn upon the horse-shoe, to the increase of the original magnetism. It will be probably impossible to establish, from the actual state of our knowledge, the mathematical law which regulates such mutual actions; but it may be very well conceived how they should augment the magnetisation throughout the whole length of the horse-shoe. Now, suppose that the magnet, instead of being applied to the polar faces, be placed at a certain distance from the poles, on a line, *mm*, perpendicular to the branches of the horse-shoe. Then the magnetisation is found to have increased in that part between *m m* and the heel, whilst it is decreased elsewhere. This may be regarded as the consequence of another fact, viz., that if a straight magnet and a bar of soft iron are arranged so that their axes cross at right angles, towards the middle of the iron bar, the latter becomes magnetic, and a *consequent point*—a double pole—is formed in that portion which is opposite to the pole of the magnet. Reciprocally, if two bar magnets be placed following one another, with their similar poles together, and upon their line of contact a bar of soft iron be placed perpendicularly to the common direction of the magnets, it is very clear that the two magnets will tend to impart the same magnetisation, and that therefore the reaction will augment that of the magnets. (The opposite effects may be produced by *reversing* the conditions of the experiment.) Each of the branches of the horse-shoe magnet may be considered as formed by the joining of two magnetic bars whose poles of *contrary* name touch at a point conformably to the line *m m*. And as the bar included between this line and the heel is more strongly magnetised than that portion between it and the poles, it follows, from what has just been said, that the application of an armature on the line *mm* should increase the magnetisation on its heel side and diminish it on its polar side. On attaching an armature to the polar faces of a strongly magnetised iron horse-shoe magnet, and on plucking it off several times, the magnetisation is diminished throughout the whole length of the magnet; but the decrease is very small, and seems to be solely due to molecular shaking. But when this plucking off of the armature takes place at a distance more or less remote from the poles, then the permanent modifications produced are much more complicated. To illustrate, let the armature be put first on a determined line *m m*; after the armature is wrenched off a diminution of magnetic intensity is noticed throughout the whole length of the magnet; but if the *wrenches* are continued on the same line a limit of decrease in magnetisation will soon be observed. Then if we place the armature on another line, *m' m'*, situated at a certain distance from the first, a further magnetic decrease may be obtained, subject also to a limit. The same process may be carried on several times, but the decrease will only be continued to a definite limit; for on reaching a certain limit the wrenches effected on a definite line, though they will continue more or less to weaken the magnetisation between the poles and that line, will yet slightly augment it towards the heel. Lastly, it is found that when magnetisation has been reduced to a very low limit, further pluckings off of the armature do not sensibly alter the magnetic condition on either one or the other side of the line."

Annalen der Physik und Chemie, von J. C. Poggendorff Band clii., 1874, No. 5.

On Direct and Indirect Determination of the Poles in Magnets.—Th. Petruschewsky.—We shall give this paper *in extenso.*

On a Simple Apparatus for producing Ozone by means of Electricity of High Tension.—W. Wright.—Taken from the *American Journal of Science*, Ser. III., vol. iv., p. 26.

Conversion of Ordinary Phosphorus into the Amorphous Form by means of Electricity.—Dr. Geissler.—The most simple apparatus used in these experiments is an exhausted glass tube, of about 35 c.m. in length and 2 c.m. in diameter. The conducting wires were fused in at the ends, so that their extremities were at least 45 c.m. (?) apart. The tube was filled with the vapour of phosphorus of very low tension. After the experiment the sides were covered with a thin layer of amorphous phosphorus, varying in colour from a brownish-red to a golden-yellow.

Spectra of Lightning.—Th. Hoh.—I never saw the spectral phenomena produced by lightning, first described by H. Kundt (*Pogg. Ann.*, Bd. cxxxv., p. 325), so beautifully and distinctly as in a violent storm which passed over Bamberg, April 23rd, between 5 and 6 P.M., in a direction from W.N.W. to S.E. My apparatus was a small "direct vision" spectroscope, of 9 c.m. in length (without telescope), the slit of which was open about ¼ m.m. Turning it to the quarter of the heavens where the lightning was to be expected, I saw first the spectrum dark, but still distinct in its colours, with the strongest Frauenhofer lines. Three or four times there appeared in the yellow and green a diffused, but recognisable illumination, followed each time by thunder within ten to fifteen seconds, and probably due to sheet lightning. Afterwards I observed ten times the spectrum of lightning. In three cases the phenomenon consisted merely of a bright illumination and expansion of the green zone over a part of the blue. In two there was a well-defined appearance of the yellow sodium line, and a fainter one in the red. In the other five cases there were distinct and brilliant lightning spectra, of linear form and rare beauty. Before the splendour of the fine lines the local colours certainly vanished, but their position could be distinctly perceived. I believe that I always counted two to three lines in the red, one each in the yellow and the orange, three or four in the green, sometimes one in the violet. An intense flash, about 20 minutes before 6, which set fire to the town, showed, in addition to the above, a group of five lines in the blue.

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* See "TELEGRAPHIC JOURNAL," vol. ii., p. 257.

No. 6.

On the Medium in Electric Induction.—Dr. H. Brongersma.—Will appear in a future number.

The American Journal of Science and Arts.

No. 45, September, 1874.

Increase of Magnetism in a Bar of Soft Iron upon the Reversal of the Magnetising Current.—William A. Burnham.—Will also appear in a future number.

On the Effect of Longitudinal Vibrations upon Electro-Magnets.—E. L. Carney.—If a bar of iron or steel which is rendered magnetic by a magnetising spiral receives a sharp blow or shock, an induced current is generated in a coil of fine wire, which is slipped upon the bar, and is connected with a galvanometer. This current is opposite in direction to that of the magnetising current. This investigation was undertaken to ascertain the effect of the excursion to and fro of the particles of the iron in the state of longitudinal vibration. The conclusions are as follows:—(1). When the primary magnetising circuit was made and instantly broken, a tertiary current was excited by the vibration, which was less in amount, and opposite in direction to the secondary current arising from the magnetism of the bar. (2). When the primary magnetising circuit was made permanently, or, in other words, while the bar was a permanent electro-magnet, the tertiary currents were in the same direction as the secondary, and in the case of soft iron uniformly greater. (3). When the rod formed the core of the magnetising helix, the tertiary currents were in the same direction as the secondary currents; and when the magnetising circuit was broken they were, in the case of soft iron, greater than the secondary currents. (4). When the magnetising circuit was made while the rod was in a state of vibration, the tertiary currents were opposite in direction to the primary, and in several instances more than one was obtained at each trial.

Experiments on the Dissipation of Electricity by Flames.—J. W. Fewkes.—This and the following paper we propose to print *in extenso.*

Polarisation of the Plates of Condensers.—A. S. Thayer.

City and Commercial Notes.

The second ordinary general meeting of the shareholders of the Brazilian Submarine Telegraph Company was held on the 14th ult. at the City Terminus Hotel, under the presidency of the Right Hon. Viscount Monck, chairman of the Company. It appeared from the report and the balance sheet to the 30th of June last, that the share capital had been fully paid up, with the exception of the small sum of £395, which is in course of liquidation. The directors, on the 10th of November last, were compelled to announce the postponement of the opening of the Lisbon-Madeira section; the efforts of the contractors to pick up and repair a fault in the cable having, in consequence of continuous bad weather, and loss of grapnel rope, ended in its breakage. Owing to the lateness of the season, the directors considered it advisable to consent to a proposal of the contractors to defer sending the second section to sea until the spring of this year. On the 18th March, the Madeira-St. Vincent section of 1260 miles, was successfully completed and opened for traffic. On the 17th June the Lisbon Madeira line was recovered from depths of over 2400 fathoms, and repaired. On the 23rd June, the last section between St. Vincent and Pernambucco, consisting of 1953 miles, was laid, and telegraphic communication established between Europe and Brazil. The cables are in satisfactory working order. The directors take this opportunity of acknowledging the valuable assistance rendered by the Governments of Portugal and Brazil during the laying of the cable, and the support they continued to give to the enterprise. Working arrangements had been concluded with the Eastern Telegraph Company, the Western and Brazilian Company, and the West India and Panama Company, by which the continent of South America was placed in direct communication with India, China, Australia, and the United States. From the opening of the line on the 23rd June to the 25th September, notwithstanding interruptions on the lines south of Pernambuco, the total receipts amounted to £24,471, showing a profit at the rate of nearly 6 per cent per annum. The directors had nominated Sir Thomas Fairbairn, Bart., to a seat at the board. The Chairman, in moving the adoption of the report, first congratulated the shareholders on the manner in which the capital had been paid up, and on the condition of the line. The accounts showed a still outstanding balance of £653 of arrears on calls; that was up to the 30th of June last; but the amount had since been reduced to about £300, and that was but a small amount considering the amount of capital invested. The cable could not be in better condition; it was working admirably, and there was every indication of its being a lasting work. The Chairman dwelt on the difficulties arising from the delay in the laying of the cable, which delay he was disposed to refer entirely to the inclemency of the elements. The contractors had exhibited the utmost energy and zeal to attain the laying of the first section from Lisbon to Madeira by July, 1873. The cable broke in the laying, and lay for about eight months in the bed of the ocean; but had been recovered 2000 fathoms in June last. The contractors had paid the directors £6500 for the delay. The Chairman traced the difficulties which the postponement of the laying of the cable had led to. The directors had to send out a staff of clerks in anticipation of the cable being laid. The expenses in this direction at Madeira, St. Vincent, and Pernambuco, had been considerable. He believed that the working arrangements with the various companies would ultimately lead to profit, but at present there were two extensive gaps in the communication. The links, however, were expected to be completed by the end of the year. Since 1st July and 1st October forty-six messages on the average had been conveyed. This might be considered a small amount, but it must be remembered that telegraphy was new to the people of Brazil. A kindred company, the Anglo-American Company, had only despatched twenty-nine messages in the first three months of their existence. Since its opening, the Brazilian Company had been taking about 6 per cent on its capital. The Chairman then stated that 137 knots of spare cable, which had been accidentally omitted from the report, came to the credit of the Company, the value of the cable being estimated at £18,000. He believed the future prospects of the Company to be most encouraging. As to a dividend, the board expected to be able to declare one next year, and he concluded by thanking the shareholders for the confidence they had reposed in them. Sir James Anderson, a director, seconded the motion. Mr. Stuart complained of the large sums paid for commissions to brokers on the formation of the Company; but the Chairman replied that it was only by obtaining trustworthy information that they could ensure calls being paid up. The auditors, Messrs. Henry Dever and John Gane, were re-elected, and the proceedings concluded with a cordial vote of thanks to the Chairman and Directors.

The half-yearly meeting of the shareholders of the Anglo-American Telegraph Company, Limited, was held on the 16th ult. at the London Tavern, Bishopsgate Street, the Right Hon. Viscount Monck, Chairman of Directors, presiding. The Chairman said the meeting was held in pursuance of a resolution passed at the last meeting, for the purpose of giving a statement with respect to the Company's affairs. Since they last met a new cable had been successfully laid across the Atlantic, and it had been paid for out of the funds of the Company without any call being made upon the shareholders. A new maintenance ship, in the place of the *Robert Lowe*, which was lost, had been purchased, and it had been found very useful in repairing the flaws in the cables which had occurred a few months ago, by which communication between this country and America was interrupted for twenty-four hours. Some influential members of the Senate of Canada had introduced a Bill into that House, the effect of which would be to confiscate the Company's property, and the Bill had been read a second time before the directors were aware of its existence; and whilst it was awaiting the expression of her Majesty's pleasure the representative of the Company went to the head of the Colonial Office to induce him to withhold her Majesty's sanction. As yet no official information on the point had been received. There was also a chance of the Company's monopoly in Newfoundland being purchased by the Government of the place. The Direct United States having carried their cable from New Hampshire to a bay off the coast of Newfoundland, an injunction to prevent them landing on the coast of Newfoundland had been granted to the Anglo-American Company. The drain upon the company's finance had been exceptionally great during the past half-year, but the outlay had been such as would result in a great accession of revenue in the future. Sir John Wilson said that for the benefit of himself and others who lived at a considerable distance from the Stock Exchange, there ought to be a periodical publication of the Company's accounts, instead of their being kept almost a secret. The Chairman said that a resolution had been passed by the shareholders some three or four years ago against the publication of the accounts. Information on the point could be obtained at the Company's offices. The directors had not the slightest desire to keep the Company's affairs from the knowledge of the shareholders; if it were their wish to have the accounts published periodically, they would only have to rescind the former resolution. He then said that, although there had been a slight diminution in the receipts during the past half-year as compared with the corresponding half-year of 1873, still, within the last few weeks, there had been an increase. A dividend at the rate of 5 per cent was declared.

The ordinary general meeting of the West India and Panama Telegraph Company was held on the 21st ult., at the City Terminus Hotel, Mr. C. W. Earle in the chair. The report, which was taken as read, stated that the amount accruing on revenue account is £20,888 3s. 8d., and that the expenses have been £20,072 14s. 9d., leaving a balance of £815 8s. 11d., which has been placed to reserve account. The Chairman said that the statement of accounts which had been given was made up for nine months, to make the Company's year of operations conform to the ordinary period of the calendar, and it gave, too, five months of the present Board's operations. The accounts related to a period which had been most expensive, apart from the general work of the Company, for in those months there had been no fewer than five general meetings, and the Board had had to send out large additions to the staff in the West Indies. The costs had been great, but it could not be hoped that the charges on the debit account would be lessened, for the directors would have to provide a ship, and there would be other heavy expenses. The condition of affairs when the directors took office was excessively embarrassing and complicated. There had not been, as the shareholders knew to their cost, a farthing of dividend earned by the Company, and for this there were various causes. The first cause was the condition of the cables, and through this the revenue had been lost, the subsidies had been suspended, and the business almost destroyed. The state of the cables was owing primarily to their manufacture, and then to the mode in which they had been submerged. The consequence was constant interruptions in the traffic. The immediate result was immense disappointment to the public who were customers, and the want of confidence which arose in the public seemed to have acted upon the staff; hence the disastrous state of the returns. Notwithstanding this position, there was considerable hope expressed in the company, and it was seen that there was a good business to be done if the Company could could only do it. This opinion was still held, and it was considered by those best able to judge, that the Company's lines were laid in one of the best quarters of the globe. The directors were not disposed to consider these opinions exaggerated, and the first movement they made was to send out a gentleman as superintendent who comprised within himself the abilities of an electrician, an engineer, and a superintendent. The effect of his working was such that a message which formerly took forty-eight hours to send occupied only three, and to show what could be done, a message had been sent from Demerara to London in one hour and forty-eight minutes. The directors did not propose to apply for the subsidies until the line was completed by the duplication of the lines in progress, strengthening the Company's system. The future of the Company depended upon the traffic it got, and it was now able to say it was in a position to do business. Mr. Ford seconded the motion for the adoption of the report. Several questions were put, and in answer to some the chairman stated that the amount of the subsidies in all was £17,800, and that the suit was still pending with the construction company. The report was adopted *nem. con.* Sir J. Anderson and Mr. W. Andrews were elected directors, and the meeting closed in the usual manner.

At the half-yearly meeting on the 13th ult. of the Eastern Extension, Australasia, and China Telegraph Company, Limited, a dividend of 1½ per cent was declared; an interim dividend of a similar amount has previously been paid. Some of the shareholders drew attention to the desirability of amalgamating with the Eastern Telegraph Company, or the Globe Company, but no resolution was arrived at, the general feeling being that it is a matter which may safely be left to the directors to deal with.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Oct. 29.
Stock	Anglo-American (Limited)	100	81—82
10	Brazilian Submarine..	All	7½—8
10	Cuba	All	6—6½
10	Direct Spanish	9	..—..
20	Direct United States Cable	All	..—..
10	Eastern (Limited)	All	8—8¼
..	Do., New	..	101—104
10	Eastern Extn. Australia and China	All	8—8¼
10	Globe Telegraph and Trust	All	7⅜—7⅝
10	Do., 6 per cent Pref...	All	10—10¼
10	Great Northern	All	10¾—11¼
25	Indo-European	All	17—18
10	Mediterranean Extension (Limited)	All	4—4½
10	Do., 8 per cent Pref...	All	10½—11
10	Panama and South Pacific	2½	..—..dis
8	Reuter's..	All	11—11½
Stock	Submarine	100	204—209
1	Do., Scrip	All	1⅞—2⅛
10	West India and Panama	All	3¾—4
10	Do., 10 per cent Pref.	All	9¼—9¾
20	Western and Brazilian (Limited) ..	All	11¼—11¾
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	104—106
10	Hooper's Telegraph Works	All	13—13½
50	India-Rubber and Gutta Percha ..	All	21—23
Cert.	Submarine Cables Trust	100	107—110
12	Telegraph Construction	All	28½—29½
100	Ditto Ditto 7 per cent Bonds	All	103—105

The number of messages passing over the Cuba Submarine Telegraph Company's line during the first fortnight of September was 916, estimated to produce £1000, against 641 messages, producing £650, for the corresponding period last year.

Patents.

ABRIDGMENTS OF PROVISIONAL AND COMPLETE SPECIFICATIONS.

452. H. Smith, of the city of Dublin. *Improvements in or in connection with window-blind raising, lowering, and arresting apparatus, and in blind-rollers, parts of such improvements being applicable to boat, telegraph cable, and other weight-lowering and arresting and holding apparatus.* Dated February 4, 1874.—One arrangement consists of a weighted lever and cam, between jaws and bed-plate; the rope or cord passes between cam and bed-plate: by raising weighted end of lever the cord is free to travel through; by letting it fall, its course is arrested by cam jambing it. Several weighted levers are sometimes used, the weights on same being adjustable as well as cam, according to the size of rope used. A modified arrangement is described, consisting of a weighted lever, which raises a pawl out of ratchet teeth, and allows the rotation of blind-roller; by releasing lever the pawl falls, and stops the rotation of ratchet and blind-roller; the ratchet and pawl are boxed up. Blind-roller caps are made so as only to grip the ends of roller at intervals, so that blinds may be secured close up to side of window-fitting. Particularly applicable to Venetian and ordinary linen blinds; also to boat lowering, to lowering and arresting telegraph cables, to raising and lowering maps, weights, and the like purposes.

485. J. J. Harrop, of Manchester, in the county of Lancaster, lead-merchant. *Improvements in the manufacture of tin-lined lead piping, and of tin and lead piping, and of soil and water pipes, and in the apparatus employed in such manufacture, and in the covering of telegraph cables with lead.* Dated February 6, 1874.—According to this invention, when making tin-lined lead piping, the ingot is cast in the press. The core bar is carried by a cross head which is connected with the ram head, so that the core bar moves at the same speed as the die. When a rising container is used the ingot is cast on the remainder of the previous ingot left in the container, the pipe issuing downwards through a sliding tube. When covering a cable with lead, the cable passes upwards through the last-named tube. A second part consists in supplying water to the inner rams by means of pipes sliding in glands on the supply-pipes. Another part consists in heating the container by means of mixed gas and air. The winding-drums are driven by power, and in some cases by means of a differential motion, and the coiling of the tube is regulated by a transversing guide.

H. Elder, of Easter Bearford. *Improvements in railway brakes.* Dated February, 1874.—The feature of novelty which constitutes this invention is the arrangement and construction of apparatus, whereby the brake blocks are applied to the wheels of all or a number of the carriages constituting the train. The invention, as applied to an ordinary signal wire or chain, consists in attaching the wire or chain to both ends of a metal side or bar perforated with closely drilled holes, or dentated or notched, into which a grapnel, which is attached to a lever and furnished with teeth or with one or more studs, drops down an inclined plane, at once securing the slide or bar by pulling the lever over, thus showing an "all right" signal. After the passing of a train, or when the "danger" signal is required, the lever is reversed, and the grapnel thus forced along a groove until it detaches itself from the slide or bar by running on rollers up an inclined plane. The wire then adjusts itself by a back weight or spring.

515. W. F. Reynolds, of Nightingale Lane, London Docks. *Improved means of and apparatus for indicating the speed of engines.* Dated February 9, 1874.—This consists in the employment of a wire strip which can be heated by a current of electricity, and be expanded lengthwise, whereby to operate an index hand and show the number of rotations of an engine.

596. C. J. Wollaston, of 8, Park Place, Marylebone. *Improvements in railway recording apparatus.* Dated February 17, 1874.—This Provisional Specification describes recording, on a uniformly travelling strip of paper, the times of sending the electric signals, and of moving the signal and switch levers.

640. W. H. Davies, of 17 and 18, Cornhill, and F. H. W. Higgins, of 17 and 18, Cornhill. *Improvements in electric telegraphs for giving signals and alarms.* Dated February 19, 1874.—This Provisional Specification describes connecting a large number of stations to a central station. The transmitting instrument is provided with, say, four finger keys. Depressing one of these keys causes a cam wheel to revolve once, twice, thrice, &c., according to the key. The revolution of the cam wheel transmits a signal consisting of a number of dots or dashes variously arranged, the cam wheel at each station being of a different form; and the signal is repeated once, twice, &c., according to the key depressed. Thus at the receiving station, the station from which the signal was sent, and what is wanted can at once be seen. An automatic fire alarm is also described in connection with this arrangement.

673. I. Baggs, of Surbiton, in the county of Surrey, practical chemist and electrician. *Improvements in electric telegraphy, and in the arrangement of apparatus employed therein.* Dated February 23, 1874.—This invention consists, first, in arrangements of apparatus and methods of working the same, whereby great force and intensity is given to very faint currents or impulses of electricity; secondly, in giving a directive force to currents of electricity, so as to cause them, as may be desired, to traverse one or other of two remote arrangements of apparatus connected with the same line wire, and without the movement, in such case, of a needle, armature, or other analogous mechanical appliance; and thirdly, in arrangements for sending a duplex message through instruments at one and the same time.

764. R. V. Dodwell, of Leadenhall Street, in the city of London, electrical engineer. *Improvements in the method of and means for producing electrical signals, and in registering or recording the same.* Dated March 2, 1874.—The invention consists in the application and use of a beam or ray of light suitably prepared by being passed from a battery through an induction coil and vacuum tube, and submitted to the action of an electro-magnet, whereby the ray of light is influenced, and deflections or movements are produced, and signals thereby effected; and in registering or recording such signals upon sensitised surfaces by intensifying the light and projecting it thereonto by means of a suitable arrangement of lenses.

To Correspondents.

⁂ Duly authenticated contributions, theoretical and practical, on every subject identified with the interests of which "THE TELEGRAPHIC JOURNAL" is the organ, will always command attention. Anonymous correspondence will be wholly disregarded. Literary communications and books for review should be addressed to the EDITOR; business communications to the PUBLISHER.

W. DEARDEN.—Received, with thanks. Second letter too late for reply in present number.